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SPACER FABRIC DEVELOPMENT, (U)  
APR 57 H H BRANDT, A RIDDELL

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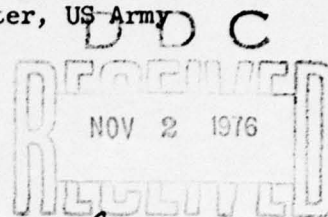
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TEXTILE, CLOTHING & FOOTWEAR DIVISION

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6 SPACER FABRIC DEVELOPMENT ✓

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by

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## SPACER FABRIC DEVELOPMENT

### 1. Introduction

For many years man has been faced with the problem of keeping warm in cold climates without becoming so burdened with clothing that he becomes immobilized. An early solution was the use of animal skins, with the hair still attached, for clothing and for covers at night. This practice is still in use in some parts of the world, but obviously sufficient animals of the right type are not available to supply armies. Another early solution, which is still used, incorporated battings into the clothing and covers. Battings, however, tend to compress and to shift, producing unevenness.

As textile knowledge increased, efforts were directed toward obtaining fabrics with high bulk-to-weight ratio and high durability. Such efforts resulted in the blankets as we know them today. Also, double-faced wool pile fabrics were developed with a high bulk-to-weight ratio and considerable durability for use in cold weather combat clothing. At a later date the QMC developed a double-faced frieze to reduce weight and conserve critical wool while maintaining the high bulk-to-weight ratio. This frieze is a cotton fabric with loops of mohair or coarse wool yarns on both sides.

With the introduction of weapons which produce a high heat source of short duration, ways for providing the individual with some protection from this high heat were investigated. It was found that the high bulk-to-weight fabrics used in cold weather clothing would also offer considerable protection from the high heat sources. However, such fabrics could not be used in hot weather clothing systems since they imposed too great a heat load on the individual. Further investigation revealed that the protection afforded by two lightweight materials could be increased materially simply by separating the two fabrics by a short distance. The problem then became one of keeping the two fabrics separated by the proper distance without imposing an excessive weight or heat load on the individual during hot weather.

### 2. Approach

An examination of the spacing problem for hot weather clothing ensembles indicated several approaches. One approach would be to utilize the spacer in an ensemble to increase the comfort as well as thermal protection. It was found, however, that the required thickness of the spacer to obtain increased comfort would result in a very thick and cumbersome ensemble. In addition, the design features of the ensemble to take advantage of the potential increased comfort factor appeared to be such that the ensemble would not be able to meet other required military characteristics. Another approach would be incorporation of the spacer



to increase only the thermal protection to the point where the ensemble would meet the required military characteristics. This approach requires that all components of the ensemble be as light in weight as possible to avoid imposing too great a heat load on the individual.

Many methods for producing spacings and/or high bulk-to-weight ratios were studied. These included woven and knit fabrics and constructions such as pile, frieze, honeycomb, waffle, terry, mesh, chenille, seersucker, etc. These fabrics were all considered unsatisfactory for use in hot weather clothing ensembles either because they were too thin to provide the required degree of protection or, if sufficiently thick, were so heavy that they would impose an intolerable heat load on the individual.

About 1950, Dynel fibers were introduced in this country but did not find acceptance in military fabrics to any great extent due, in part, to their susceptibility to heat. A re-examination of woven and knit Dynel fabrics was made. It indicated that they could be deformed under certain conditions and protrusions of almost any desired height and spacing could be obtained, a method being used to produce Dynel hats for summer wear. The protrusions thus formed did not appear to hold too much promise, however, since they did not recover well after compression.

### 3. Spacers for Thermal Protection

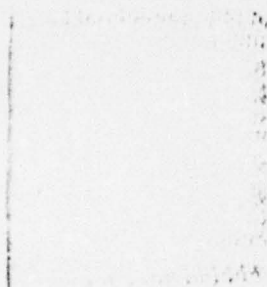
Industry recently has introduced fabrics in which novel effects were obtained by combining fibers having a high degree of shrinkage in boiling water with those having a low degree of shrinkage and then subjecting the resulting fabric to boiling water. Many novel effects can be obtained by changing the manner of incorporating the shrinkable and non-shrinkable fibers or yarns in fabrics produced by normal methods. Using this approach, a fabric (VEE347) was designed in a leno weave and produced from both high shrinkage and low shrinkage polyethylene monofilaments. After being subjected to boiling water, the fabric resembles a corrugated material of very open construction. It has a weight of 4.9 ounces per square yard and is 0.24 inches thick when measured under a pressure of 0.01 pounds per square inch. The construction of this fabric is presented in Table I and Fabrics 2 and 2A of Figure 1 show different views of the fabric.

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# SHRINK FABRIC

1

Off the loom  
before shrinkage



1/8"

1A

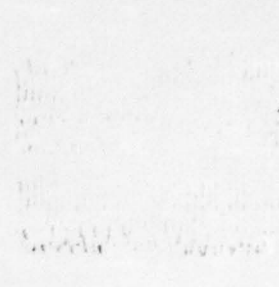
After Shrinkage



5/8"

1B

After Shrinkage



7/8"

2

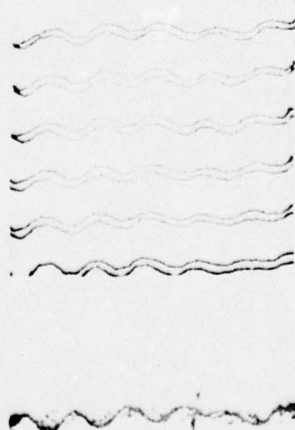
Off the loom  
before shrinkage



0"

2A

After Shrinkage



2/8"

Fabrics 1, 1A, 1B are made with Polyethylene (shrinkable), and Saran (nonshrinkable) fibers.

Fabrics 2, 2A are made with Polyethylene (shrinkable) and non-shrinkable fibers.

FIGURE 1

3

# TABLE 1. CUMULATIVE 3 INCH FABRIC

	VEE347		VEE490		VEE491	
	Off the Loom	Finished	Off the Loom	Finished	Off the Loom	Finished
Weight, per square yard	1.92	4.90	30	55	30	55
Ends per inch-non-shrinkable	16	18	39	42	39	42
Ends per inch-shrinkable	5	6	59	62	59	62
Picks per inch-non-shrinkable	12	26	59	104	58	96
Warp yarn, non-shrinkable	400 Den. Mon.	Poly.	3140 Denier Monofilament Saran			
Warp yarn, shrinkable	600 Den. Mon.	Poly.	600 Denier Monofilament Poly.			
Filling yarn, non-shrinkable	400 Den. Mon.	Poly.	1130 Denier Monofilament Saran			
Weave	Plain and Leno		Plain, 5 ply fabric			
Width in inches	44.5	38	57.6	54.2	57.8	54.4
Shrinkage in finishing non-shrinkable warp, %				6.9		6.5
Shrinkage in finishing shrinkage in warp, %		52		44.1		39.2
Shrinkage in finishing, non-shrinkable filling, %		14		5.9		5.9



#### 4. Evaluations

Using the Instron Compressometer, with the plunger speed set at 0.02 inches per minute, thickness measurements were made under loads of from 0.01 to 10.0 pounds per square inch. The 10.0 psi load was maintained for 5 minutes after which the fabric was allowed to relax for 5 minutes before repeating the load cycle. These data are presented in Table II. It should be pointed out that this fabric showed only 20 percent of its original thickness when the 10 psi load was applied but recovered to 70 percent of its original thickness within 5 minutes after removal of the load.

TABLE II - COMPRESSION OF CORRUGATED LENO-TYPE FABRIC

<u>Pounds per Square Inch Press. *</u>	<u>Thickness in Inches First Cycle</u>	<u>Thickness in Inches Second Cycle **</u>
0.01	0.238	0.169
0.1	0.196	0.138
0.2	0.182	0.129
1.0	0.177	0.127
2.0	0.121	0.097
3.0	0.080	0.057
5.0	0.079	0.056
10.0	0.047	0.046

\* Instron Compressometer plunger speed set at 0.02 inches per minute.

\*\* The 10.0 psi pressure was applied for 5 minutes at the end of the first cycle and then a 5 minute relaxation period allowed before start of the second cycle.

Table III presents thickness data on the fabric when subjected to repeated loadings of 12 pounds per square inch for extended periods followed by relaxation periods.

TABLE III - COMPRESSION OF CORRUGATED LENO-TYPE FABRIC\*  
UNDER REPEATED LOADINGS OF 12 PSI

Load on Specimen Hours	Immediate Thickness Inches**	Thickness after 5 Min. Relaxation (No load) Inches**	Relaxation Time (No load) Hours	Thickness After Relaxation, Inches**
3.5	0.034	0.128	3.5	0.140
7.5	0.042	0.123	16.5	0.219
7.5	0.037	0.123	16.5	0.199
7.5	0.034	0.116	16.5	0.176
7.5	0.032	0.114	90.5	0.174
7.5	0.032	0.114	16.5	0.167
7.5	0.031	0.106	16.5	0.164

\* Original thickness under 0.01 psi equals 0.238.

\*\* Measured under 0.01 psi.

Finally, laboratory arc studies were made on this fabric. These studies indicated that an ensemble composed of (1) a fire resistant treated standard cotton poplin as the outerlayer, (2) this spacer fabric as the intermediate layer and (3) standard cotton T-shirt material as the inner layer would exceed the present military characteristics for thermal protection.

The results of the hot weather clothing design studies of the polyethylene spacer fabric will be presented in another report. These studies showed that the polyethylene fabric cannot be placed in contact with the skin without producing irritation within a very short period of time. However, when a light (3.5 ounces per square yard) cotton T-shirt material is worn under the spacer fabric it is sufficient to prevent damage to the skin.

Several fabrics which are being developed on a Quartermaster Research and Development contract show more promise from the standpoint of reduced irritation to the skin than the spacer fabric reported above. One of these weighs about 3.3 ounces and has some cotton on one side. The other will weigh 5 to 6 ounces and will have soft yarns on one side. It may be possible to use one of the fabrics in the under garment and eliminate the use of the T-shirt material.

##### 5. Spacers for Comfort

During the work on spacer fabrics for thermal protection, an idea evolved that a similar but much thicker fabric might increase the comfort of hot weather clothing ensembles if placed between the ensemble and the load carrying pack. Consequently, two fabrics which varied only in thickness were designed and produced. The constructional data for these



two fabrics are presented in Table I, while Fabrics 1, 1A and 1 B of Figure 1 show different views of the fabrics. Table IV presents thickness data for these two fabrics under loads of 0.01 to 10.0 pounds per square inch. Samples of these fabrics have been forwarded to the Clothing and the Tentage and Equipage Branches for examination and/or evaluation.

TABLE IV - COMPRESSION OF MULTILAYER SPACER FABRICS

Pounds Per Square Inch Press.*	VEE490		VEE491	
	Thickness in Inches First Cycle	Thickness in Inches Second Cycle	Thickness in Inches First Cycle	Thickness in Inches Second Cycle**
0.01	0.874	0.853	0.599	0.574
0.1	0.866	0.845	0.581	0.562
0.2	0.862	0.841	0.576	0.556
1.0	0.848	0.818	0.545	0.519
2.0	0.822	0.680	0.513	0.469
3.0	0.800	0.528	0.468	0.413
5.0	0.410	0.303	0.380	0.342
10.0**	0.211	0.194	0.187	0.183

\* Instron Compressometer plunger speed set at 0.02 inches per minute.

\*\* The 10.0 psi pressure was applied for 5 minutes at the end of the first cycle and then a 5 minute relaxation period allowed before start of the second cycle.

## 6. Conclusions

1. A spacer fabric has been developed which can be used in hot weather combat clothing ensembles to afford thermal protection meeting present military characteristics. Modifications of this fabric have been produced in very limited experimental quantities which hold potential for reducing the weight and heat load without significantly reducing the thermal protection.

2. Other spacer fabrics have been developed which appear to hold promise for increasing the comfort of hot weather clothing ensembles when placed under items such as the load carrying pack. These fabrics are being examined also in designs of the hot weather clothing ensembles and for possible use in the bottom of casualty bags.